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ABSTRACT

A hypertext application is being developed at the Open University, the United Kingdom's university for distance education, to assist with the design and study of courses by using a software implementation of a relational glossary. It is based on the established view that topics are made up of related concepts and that their relationships can be captured in an electronic relational glossary. An entry in a relational glossary contains one concept as a grammatical subject, together with explanations for this concept, consisting of grammatical predicates involving other concepts. The tool is a HyperCard stack with an interface designed to enable the production and interrogation of the stack. The relational glossary can be used by course designers to check the relationship between the concepts covered in a course and by students to check that they have understood particular concepts and the relationships between them. In addition, students can use the glossary to get "unstuck" while learning. The software is still in a prototype phase, but it is being used as a syllabus for the Open University's new introductory computing course. (AEF)

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Using a Computerized Relational Glossary for Syllabus Design and Student-Centred Study

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Abstract: This paper describes a hypertext application to assist with the design and study of courses by using a software implementation of a relational glossary. It is based on the established view that topics are made up of related concepts and that their relationships can be captured in a relational glossary. An entry in a relational glossary contains one concept as a grammatical subject, together with explanations for this concept consisting of grammatical predicates involving other concepts. These set the concept into the context created by other related concepts. The tool is a HyperCard stack with a well designed interface to enable the production and interrogation of the stack. The relational glossary can be used by course designers to check the relationships between the concepts covered in a course and by students to check that they have understood particular concepts and the relationships between them. In addition, when students become stuck, they can use the glossary to get themselves moving again.

Background

The Open University (OU) is the United Kingdom's university for distance learning. It also offers its programmes of study throughout continental Europe. In 1992 there were 136 courses in the OU's undergraduate programme and in this academic year over 126000 students have registered to study with the university. The degree programme is modular and there are relatively few constraints on how students can mix courses and subject areas.

The distance mode in which the Open University operates has a significant impact on its syllabi and its pedagogy. OU students are taught using correspondence texts, broadcast television and radio, and video and audio cassette programmes. The first of these is the main pedagogic vehicle. The relative isolation of students from their peers and tutors is important; there are no 'lab' sessions to help students, and so careful syllabus design is vital. It is also imperative that students develop independent learning skills and be provided with the means to use these skills. Therefore, in this section we set the context which has motivated us to design a computerized version of an artefact which assists syllabus design and student-centred learning.

The average age of students is 34 (mainly in the 25–45 age group) and the vast majority remain in employment throughout their studies. This makes courses that can be considered vocational very attractive to OU students; however, study is part-time and demanding. Computing courses are particularly popular for their vocational potential; the Computing Department's courses are much in demand, with over 2500 students per year taking the introductory undergraduate course alone, despite it requiring at least 400 hours of study over ten months. We have just begun the development of a new introductory course and this is the primary motivation for the work reported herein.

The current introductory course covers many topics in programming, software engineering, software systems, structured analysis and design, and the social impact of computing. Because of its level, certain assumptions are made about the ability (the self-sufficiency) of students. To some extent this has meant that the authors of the course were able to avoid some teaching of elementary study skills; however, changing regulations and governmental demands means that, increasingly, too many students do not have such skills. Furthermore, as is usual with OU courses, the introductory course for computing has no prerequisite and attracts students who have substantially different requirements of the course. For many it is the first of a number of computing courses which will build a computing profile for their degree. For others the course is a diversion

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from arts, the pure sciences or social sciences; in other words it may be used as an appreciation course. The consequence of this mix and the variable level of study skills is that any replacement must be accessible to a wide diversity of students following different academic careers. These interacting factors mean that the new course will have to provide greater assistance to students to enable them actively to explore the course syllabus, whether it be to take remedial action or to deepen their knowledge.

Relational Glossaries

One device which can be used to enable students to explore the syllabus to deepen their knowledge or take remedial action is a relational glossary – a glossary which defines the concepts in a topic in such a way as to make the relationships among all the concepts very clear (Zimmer, 1984). Before discussing how we might create such a glossary, we give three operational definitions as specified by Zimmer:

- A topic is defined as 'an agglomeration of concepts that are meant to be inherently interconnected.'
- A concept is 'anything that can be named as a noun.'
- An explanation is 'one or more sentences in which the name of the concept being explained appears as the grammatical subject.'

In addition, the relational structure of a topic must be represented in a way that is 'capable of displaying the three properties of uniqueness, completeness and connectivity' (*cf.* Pask, 1975):

- *Uniqueness*: Once one has named a concept in the topic, one never gives it another name and one never uses its name for any other concept in the topic.
- *Completeness*: One can explain any named concept in the topic in terms of other named concepts in the topic without recourse to concepts outside the topic (except for those in the everyday language of the learner).
- *Connectivity*: A thorough explanation of any concept in the topic presents several aspects of its meaning in terms of several other concepts in the topic.

TERM	RELATIONSHIPS	UNIT	SECTION
SYNCHRONISED CLOCKS at rest in any particular **inertial frame of reference**	can be thought of as all running at the same rate and reading the same **instant** in **time** no matter where they are. That is, they would all appear to read exactly the same instant in time for a hypothetical, *non-physical* being ... They are therefore exactly the same in concept *both* in Newtonian mechanics and in **Einstein's special theory of relativity**, *provided that* one thinks about them only within a *single* chosen inertial frame of reference.		
	in **Einstein's special theory of relativity**, will *not* appear to be synchronized ... (See the **relativity of simultaneity**.)	5	4.2
	in Newtonian mechanics, are *assumed* to appear synchronized *regardless* of the frame of reference from which they are observed.		
	in **Einstein's special theory of relativity**, are embodied in a **space-time diagram** by the very *existence* of an x-axis or an x'-axis, ...	5 7	7 4
	can be set up, in **Einstein's special theory of relativity**, by a simple procedure which allows for the finite **speed of light** ...	5	4.3
A **TEST CHARGE**	is a particle bearing a known *small* **charge** (usually called charge q) which is used to measure the **electric field** at a point in **space-time**. (The charge on it must be small so that its effects on the charge distributions or current distributions that give rise to the fields being measured can be considered negligible.)	4	2.2
The **THRESHOLD ENERGY** for a reaction	is the minimum **energy** required to start the reaction. This energy is usually supplied by the **relativistic energy** of an incoming particle.	7	6.5

Figure 1: An extract from a paper-based relational glossary
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In Figure 1 we give, as an example, an extract taken from an Open University course in physics (S354, 1980). In this example, each term which appears in bold print can itself be looked up in the glossary.

Such a glossary can be used by students for exploration, revision and review. All that they need to do is to browse it and follow its rich cross-referencing.

More importantly, they also can use it to get 'unstuck' when – inevitably – they get stuck from time to time while learning from the main course text. All that they need to do is to write down the question to which they need an answer in order to get moving again – and then look up in the glossary the concepts which appear in their question. Provided that the glossary has been constructed with proper uniqueness, completeness and connectivity, the explanation needed will appear immediately or else through tracing of cross-referenced terms.

Students are not the only ones to benefit from a relational glossary. While they benefit from its completed form, the very act of constructing it can be of huge benefit to teachers when designing a course – particularly where the subject matter is complex (Zimmer, 1984) and awash with jargon, as in computing. For the educator, a relational glossary encapsulates the set of topics to be covered by a course although it does not order them according to some pedagogy. Indeed, any ordering is determined by the contents of the glossary. While this benefit has been recognized, there has been a reluctance to invest in the time and effort needed to create comprehensive relational glossaries; pressure to 'get writing' often precludes their use during syllabus design.

We conjectured that a computer-based relational glossary would encourage academics to use it as an experimental tool and that it could become an effective computer-based learning tool for students. Desire for such a tool has been expressed in other parts of the OU as well (Clark, 1989). We are in the process of testing these views.

Student Use of a Computerized Relational Glossary

A paper relational glossary can be of use to both course developers and to students, but a computerized relational glossary potentially even more useful. Firstly, a teacher can use it to record the specification of a course syllabus and to check it automatically for coherence. Secondly, with appropriate support, a teacher can experiment with and design syllabi based on recorded concepts. A prototype system has therefore been developed based on HyperCard; for the introductory software development course, a production-quality system will be written using the prototype as an oracle. In this section we describe the prototype as it might be used by a student. In the next section the computer-based system is described in terms of creating the glossary. For brevity we do not describe how a user is determined to be a student or a teacher.

The structure of the information held is a straightforward organization consisting of an unordered sequence of triples containing the *concept name*, a concise *explanation* of the concept, and an unordered list of *related concepts*. Hyperlinks may be established between concepts referenced in an explanation and the descriptions of those concepts, and between related concepts and their descriptions.

It should be noted that this structure is 'looser' than the structure shown in Figure 1: for the purpose of creating our prototype, we have gone for ease of construction in preference to clarity of access. Once the system is working well, the more exacting format shown in Figure 1 can be introduced.

The HyperCard prototype consists of a 'stack' of cards containing corresponding fields as shown in Figure 2, which shows a card from a computerized glossary called 'M206 Glossary'. The concept (or term) to be described is shown in a banner heading style; in Figure 2 it is *Computer System*. The explanation is given in the below (beginning *This is the sum total...*). A list of related concepts may be shown in a narrow field below the explanation (see Figure 3); these are terms not needed in a concise explanation of *computer system*, but should be explored for a full understanding. These related topics are only shown to to a student on request, by clicking the *Show Related Concepts* button shown in the figure.

The explanation of *computer system* contains references to three other concepts; these are *operating system*, *software system* and *system*. Clicking on any of these will transfer the user to the appropriate card containing the description of the reference term. For example, clicking on *software system* moves to the card shown in Figure 3.

Normally, the text in the glossary fields cannot be modified; however, a panel of buttons for editing them and for reading from text files or other glossaries can be used using a *Show Control Panel* button. This button is not shown in Figure 2 as students would not usually see this button; it is only available to users who are teachers. In addition to the glossary fields, a typical card contains a field (on the right) where a trace of browsed terms is maintained. The empty trace in Figure 2 indicates that no concept was browsed before *Computer System*. Figure 3 shows *Computer System* in this field, indicating that its description has been the only one visited during the current browse. A card also has buttons for navigating whose functions are indicated in Figure 2.

In the prototype, the introductory card of a glossary, though of the same general structure, is used differently from the rest. It is used as a general *information* card and contains additional fields and extra operations, provided by buttons (these are mostly of use for the author of the glossary as described in the next

section). An example from the glossary being used to develop a new syllabus is shown in Figure 4. There, general information is given in the largest field, as shown.

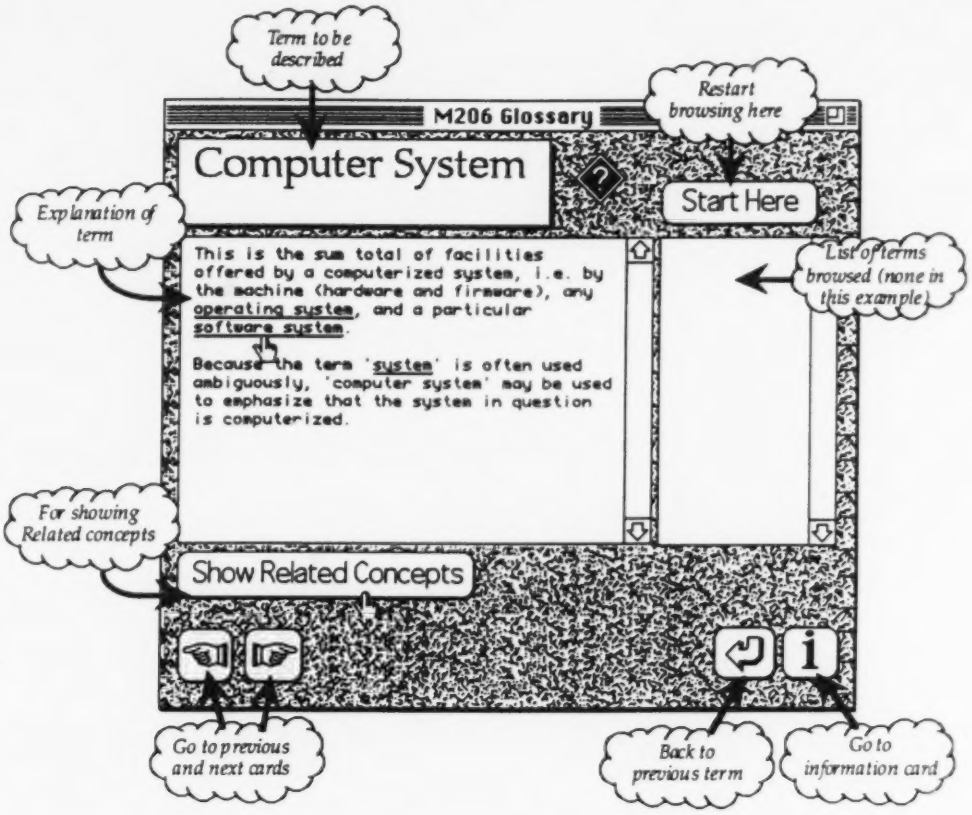
Term to be described
Restart browsing here
M206 Glossary
Computer System
Start Here
Explanation of term
This is the sum total of facilities offered by a computerized system, i.e. by the machine (hardware and firmware), any operating system, and a particular software system.
Because the term 'system' is often used ambiguously, 'computer system' may be used to emphasize that the system in question is computerized.
List of terms browsed (none in this example)
For showing Related concepts
Show Related Concepts
Go to previous and next cards
Back to previous term
Go to information card

Figure 2: Typical card from computerized relational glossary

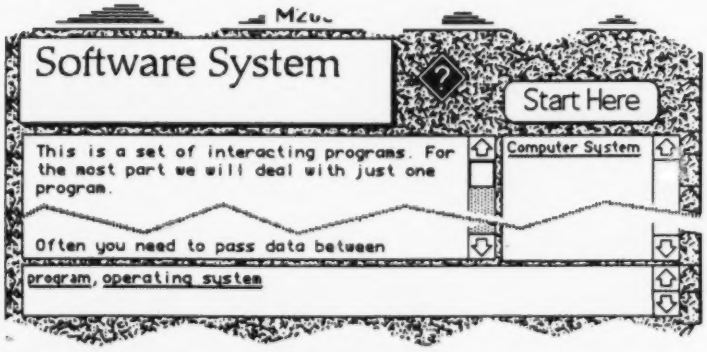
Software System
Start Here
This is a set of interacting programs. For the most part we will deal with just one program.
Computer System
Often you need to pass data between
program, operating system

Figure 3: Navigating a network of concepts

Note that the right hand field in the information card is an alphabetically ordered index to all the concepts held in the glossary. A term can be found by scrolling through the list (or using a built-in 'find' command) and the user can move directly to its explanation by clicking on the term.

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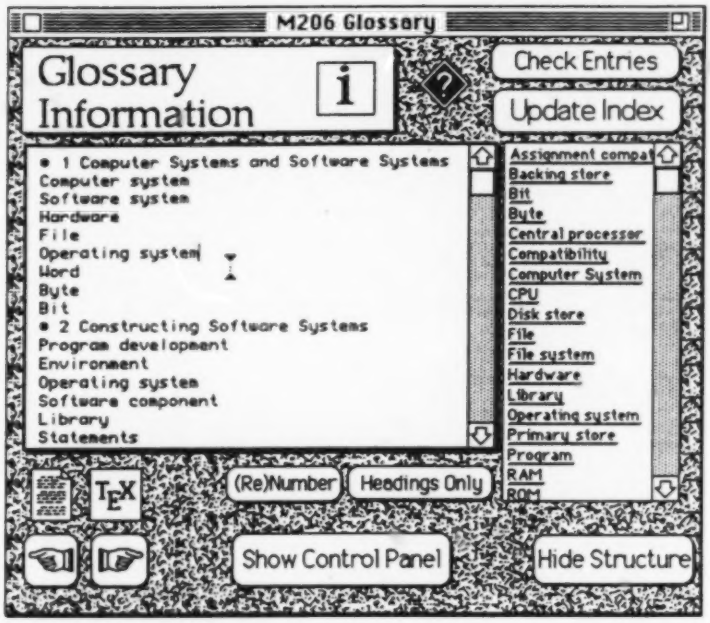

Figure 4: Sample syllabus structure

The buttons immediately under the large explanation field (shown by the general document icon and TEX) are for producing reports of the glossary according to parameters which may be set via the control panel mentioned earlier. The first generates a plain text description of all concepts, their explanations and related concepts; the text can be copied for pasting to another application or written to a text file. The second generates a LaTeX document (Lamport, 1986). The purpose of this is not just to produce an elegantly typeset document but to produce comprehensive cross references from explanations and related concepts and to produce various types of index.

Syllabus Design Using a Computerized Relational Glossary

The prototype has several facilities for experimenting with and designing a syllabus. Although a relational glossary is inherently unordered with a topic structure being like a well-woven string-bag which can be picked up and hung from almost any node, it is helpful to be able to order the concepts in some way. This facility and others are available from the *Glossary Information* card. The card now has a *Try Structure* button which, if clicked, reveals a field with a shadow style for recording concepts to be included and for ordering concepts. Also, the button changes to become the *Hide Structure* button at the bottom right of Figure 4. Using this field the syllabus designer can explore a two-level structure consisting of headings (prefixed by a bullet character) and concept names. Figure 4 shows an example of this structure in the larger field on the left. It may be edited in the usual way, so text may be selected and copied/cut and pasted. Concept names may also be copied into the structure by clicking on the index field on the right. In addition, the headings may be numbered (as in Figure 5) and the numbers recalculated or removed as desired using the *(Re)Number* button.

The report generation buttons operate somewhat differently when a structure is being developed: the user is given the option to report only on the headings, or headings and concepts.

When designing a syllabus it is often necessary to concentrate on the headings under which concepts are grouped to make a topic. The *Headings Only* button is therefore provided for use with the structure field; as the name suggests, it removes the detail of the concepts, leaving only a visual indication that concepts have been included under a heading. Figure 5 shows an unnumbered, elided version of the structure in Figure 4. The *Headings Only* button is replaced by an *Show All* button for restoring full details.

Another facility for the author of a glossary is an operation to check what concepts have not yet been entered in a glossary. The *Check Entries* button (top right, Figure 4) produces a report on the screen on topics not defined. Entries for these missing concepts may then be created automatically either en bloc or singly by clicking on the name of the missing concept. (This facility is also available for creating concepts enumerated in a structure such as that in Figure 4.)

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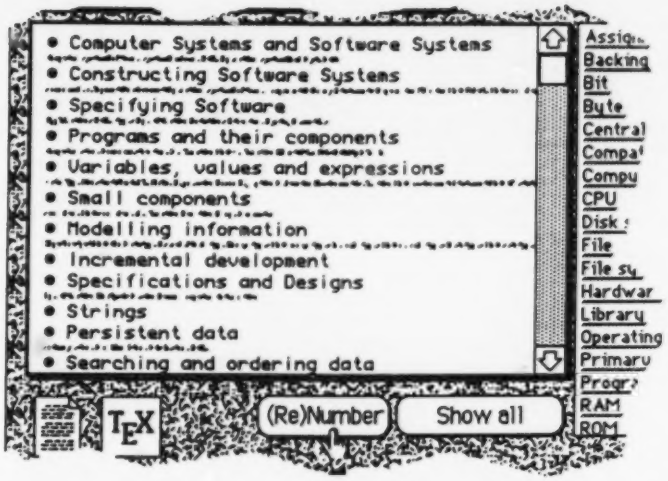

Figure 5: Elided, unnumbered structure of a syllabus

While using our prototype in the ongoing design of the new course we, as educators, have been confronted with the uncomfortable fact that we tend to introduce too many concepts early in our courses and that we often do not make good use of the concepts we have previously described. This experience supports anecdotal evidence that students find the early part of the existing course too onerous. It also shows that construction of a relational glossary during syllabus design may expose the tendency of experts to assume too much of the novice.

Conclusion

We have described a need for a computerized relational glossary for syllabus design and student-centred study and have outlined a novel tool to implement this notion.

A relational glossary can help students to revise and review and get unstuck while learning. The act of constructing it can help teachers to produce course materials of much greater conceptual clarity, whether working alone or in teams. The problem is that proper construction of a relational glossary takes time and effort. Computer software to prompt and facilitate its construction can make the process much more attractive.

The software is still in a prototype stage, but it is being used to design a syllabus for the OU's new introductory computing course. The glossary facilities have already been tested by reproducing part of an existing paper glossary of a programming language standard (ISO, 1992). The syllabus design facilities were tested by analysing and inputting to a glossary material from an existing computing course. As part of normal quality assurance process the production-quality version of the computerized glossary will be tested and evaluated by students before it is used by their peers.

We have also found that using a hypertext system for creating teaching material has indeed many of the benefits expounded by others (Thimbleby, 1992).

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